

JOIN'EM

INDUSTRIAL TECHNOLOGIES FOR ADVANCED JOINING AND
ASSEMBLY PROCESSES FOR MULTI-MATERIALS

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JOINing of copper to aluminium by ElectroMagnetic fields

Electromagnetic Pulse Welding Glossary



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1 Electromagnetic Pulse Welding Glossary

This document contains recommendations regarding the terminology used when referring to the Electromagnetic Pulse Welding (EPW) process, its parameters, equipment or used test specimens. The need for uniformizing the terminology regarding this innovative welding process has been deemed critical for the wide industrial implementation of the process. In the various sources studied, EPW has been referred to as:

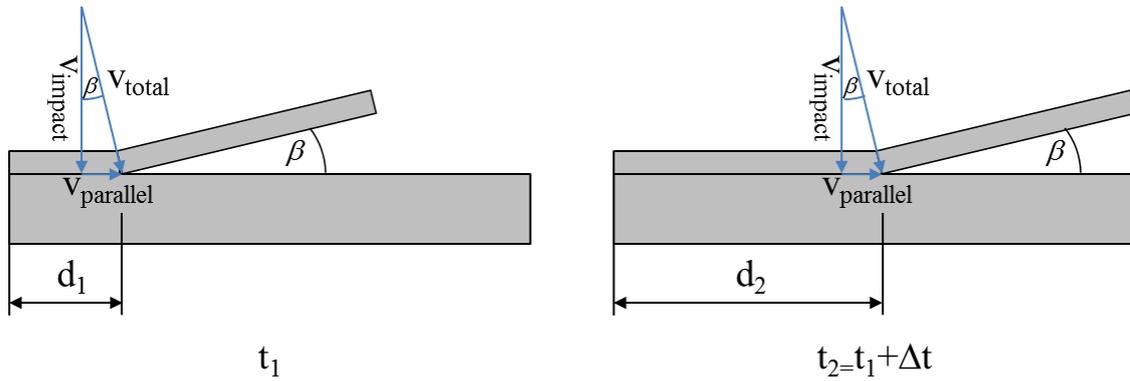
- Electro Magnetic Welding (EMW)
- Electro Magnetic Pulse Welding (EMPW)
- Magnetic Pulse Welding (MPW)
- Magnetic Pressure Welding (MPW)
- Magnetic Impulse Welding (MIW)
- Electromagnetic Pulse Technology (EMPT)
- Electromagnetic Pulse Metal Processing Techniques (EPMPT)
- Electromagnetic pulse technology (EMPT)
- Welding by electromagnetic forming

As such, it was considered relevant to harmonise the vocabulary related to the process in order to name it always the same way according to the diversity of terminology used. The terminology should be included in the ISO and IEC terminological databases for use in standardisation. This can be found online at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

For the purposes of this document, the following Terms and Definitions are proposed:

- Electromagnetic pulse crimping: creation of a crimp connection using electromagnetic forming.
- Electromagnetic Pulse Welding (EPW): creation of a welded joint using electromagnetic forming.
- Electromagnetic pulse sheet welding: creation of a welded joint of sheets using electromagnetic forming.
- Flyer sheet/tube: the sheet or tube that will be accelerated during the EPW process.
- Target sheet/tube: the sheet or tube that is stationary during the EPW process.
- Impact velocity: Normal component of the velocity of the flyer plate/tube velocity when it impacts with the target material.
- Collision point velocity: Mean velocity along the target material at which the weld moves forward.



Mean collision point velocity $v_{collision,mean} = \frac{d_2 - d_1}{\Delta t}$

Figure 1: Definition of EPW characteristic velocities
 Image courtesy of: Fraunhofer IWU

- Impact angle: Angle between flyer’s impact surface and target’s impact surface at the moment of collision.
- Jetting critical angle: Angle from which a jet is created at the collision front.
- Standoff distance: Initial gap between the joining partners; the distance by which the metals to be welded are separated from each other prior to discharge.
- Free length between the flyer tube/sheet and the internal workpiece: part of the flyer (tube or sheet) that can freely move under the effect of the magnetic forces (not hold up by the support or a part of the target part). Corresponds to the area that will be in contact after the magnetic impulse.
- Overlap of flyer and tool: Distance that the flyer workpiece overlaps with the coil or field shaper.
- Discharge energy: The set charging voltage of the capacitors and their capacitance; this is discharged into the coil. The discharge energy is characterized as follows:

$$E = \frac{1}{2} C V^2$$

E = discharge energy (J)

C = capacitance (F)

V = charging voltage (V)

- Current discharge frequency: significant frequency of the current induced in the coil from t_0 until $t_{first\ peak}$. The following figure illustrates this concept and presents the current discharge frequency equation:

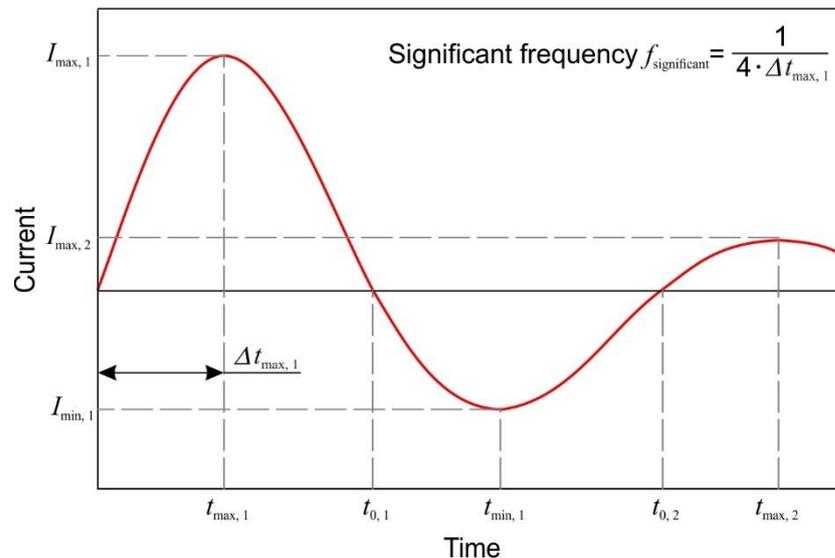


Figure 2: Pulsed current parameters
Image courtesy of: Fraunhofer IWU

- Pulse repetition rate: Number of pulses per unit of time.
- Pulse rise time: Time taken by the electromagnetic pulse to change from a specified low value to a specified high maximum value ($\Delta t_{\text{max},l}$).
- Skin effect: Alternating current tends to distribute itself inside a conductor in such a way that the current density is highest near the surface of the conductor. This is called the skin effect. This effect is caused by the eddy currents.
- Skin depth: How deep eddy currents penetrate into a material is defined as the depth at which their intensity drops to $1/e$ (about 37 %) of their original intensity.
- Bitter coil: Coil formed by stacking alternating conductors and insulating discs, each foreseen with a radial cut.
- Single turn coil: Coil consisting of one turn.
- Helix coil: Coil with the turn arranged in a helical shape.
- Flat coil: Coil with the turns arranged in a single plane.
- Rogowski coil: A toroidal coil without a ferromagnetic core to measure the discharge current in an electrical circuit.
- Pitch of the coil: Number of turns per unit of length.
- Pulsed power generator: Consists of a device that stores electrical energy and discharges it in the forming or welding coil in a very short time interval. Machine supplying the discharge energy needed for EPW.
- Field shaper: Component that concentrates the magnetic field in the forming or welding zone. It essentially increases the amplitude of the magnetic field, in a smaller region (axially). Also called 'field concentrator'.